Alternatives to Deca-BDE

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Overview

- **Uses of deca-BDE considered**
- **Available alternatives**
  - Methods for identifying alternatives
  - List of alternatives
- **Toxicity and Environmental Fate information**
  - Methods and sources of information
- **Results**
  - Summarizing toxicity, persistence and bioaccumulation information.
- **Summary**
- **Preliminary Conclusions**
- **Next Steps/Future Work**

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Uses of Deca-BDE[1]

- High-impact polystyrene (HIPS)
- Thermoset and thermoplastic polyesters,
- Polypropylene,
- Crosslinked polypropylene,
- Elastomers,
- Wire and cable insulation of all types,
- Adhesives,
- Coatings,
- Textile coatings

[1] Albemarle Corp. website, product information.

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Uses of deca-BDE for alternatives assessment

- Most (~66[2]-80[3]%) of deca used in U.S. is in HIPS (TVs) (Lowell Center, 2005)
- Feasibility: HIPS/(polyphenylene oxide) PPO can replace HIPS (cost differential)
- Alternatives were identified for use in HIPS or HIPS/PPO
  - HIPS/PPO allows non-halogen alternatives
- Currently, assessment does not consider other materials or design changes

[2] NAS, 2000. [3] Lowell Center, 2005.

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Methods for Identifying Alternatives

- Survey of electronics companies
- Existing reports
- Flame retardants product information from chemical manufacturers

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Survey of Companies

- Ecology and DOH developed a standard questionnaire
- A total of 9 electronics manufacturers were contacted
- *Low response (N=3)*
- *Reasons include:*
  - *Concerns about confidentiality/releasing business information*
  - *Unwillingness to provide information*
  - *Legal concerns*

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Existing Reports

- Sources of reports that evaluate flame retardants or alternatives:
  - Danish EPA
  - German Federal Ministry for the Environment
  - UK Environment Agency
  - Swedish KEMI
  - Lowell Center
  - CPSC/NAS
  - EPA
  - EU
- Provide varying amount of use, environmental and toxicity information
- Not specific to alternatives for HIPS

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Product Information

- Product information and other publications available from chemical manufacturers websites including:
  - Albemarle
  - Great Lake Chemical
  - Akzo Nobel
  - Hexion Specialty Chemicals, Inc.
  - Clariant GmBH
  - LG Chemical Limited
- Looked for products marketed specifically for use in HIPS or HIPS/PPO

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Evaluating Toxicity of Alternatives

- Sources of information include:
  - Existing reports
  - MSDSs for products
  - NLM Medline and Toxline Databases
  - European Inventory of Existing Commercial Chemical Substances (EINECS)
  - EPA's HPV Program
  - Information from EPA under a FOIA request
  - QSAR modeling (Accelrys Software Inc.)
  - Software for predicting K_{ow}s and BCFs (EPIWIN and EPA's PBT Profiler)
  - General Internet searches

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Identified Alternatives

- Halogen containing alternatives:
  - Bis(pentabromophenyl) ethane [SAYTEX 8010] CAS# 84852-53-9
  - 1,2-bis(tetrabromophthalimido) ethane [SAYTEX BT- 93] CAS# 32588-76-4
  - Tetrabromobisphenol A epichlorohydrin polymer [EPON Resin 1163] CAS# 40039-93-8
  - Bis(tribromophenoxy)ethane [FF-680] CAS# 37853-59-1
  - Hexabromocyclododecane (HBCD) CAS#s 3194-55-6 and 25637-99-4
  - Tetrabromobisphenol A (TBBPA) CAS# 79-94-7
  - Tetrabromobisphenol A bis(2,3-dibromopropyl ether) CAS# 21850-44-2

Identified Alternatives

- Non-halogen alternatives:
  - Resorcinol bis (diphenylphosphate) (RDP) CAS# 57583-54-7
  - Bisphenol A diphosphate (BAPP) [Refofos BAPP] CAS# 181028-79-5
  - Bisphenol A bis(diphenyl phosphate) (BDP) [Fyrolflex BDP] CAS# 5945-33-5
  - Diphenyl cresyl phosphate (DCP) CAS# 26444-49-5
  - Triphenyl phosphate (TPP) CAS# 115-86-6
  - Zinc Borate, CAS# 1332-07-6

Identified Alternatives

- Related chemicals:
  - Polytetrafluoroethylene (PTFE) [Teflon] CAS# 9002-84-0
  - Antimony trioxide, CAS# 1309-64-4

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Compiling Toxicity Information

- Developed a standardized toxicity profile form
  - Based on toxicity profiles in German, Danish and EPA reports
- Data compiled in draft Appendix B for Deca-BDE, alternatives and related chemicals

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Toxicity Profile Parameters

- Profiles include:
  - Identifying and product information
  - Physical and chemical properties
  - Epidemiological information
  - Toxicity information:
    - Acute and subchronic toxicity studies,
    - genotoxicity/carcinogenicity, reproductive/developmental toxicity studies,
    - Neurotoxicity studies,
    - Toxicokinetics studies,
    - Ecotoxicity studies.
  - Environmental fate
    - Degradation
    - Half-life
    - BCF
  - Ecology's PBT Criteria

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Summarizing Alternatives

- Developed a matrix to compare alternatives across different parameters
- Based on summary table/matrix developed by EPA for alternatives to Penta-BDE in low-density furniture foam (2005)

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Summarizing Information on Alternatives

- Reactive or additive?
- Ranking of toxicity concern
  - Low, medium, high or no/insufficient information
- Ranking of ecotoxicity concern
  - Low, medium, high or no/insufficient information
- Ranking of availability of toxicity information
  - Low, medium or high
- Is there information on potential routes of exposure?
  - Yes/No
- Persistence and Bioaccumulation Potential
  - according to Ecology's PBT definition
  - Yes/No
- Is chemical a PBT?
  - according to Ecology's PBT definition
  - Yes/No

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Table 1. Summary of use, persistence, bioaccumulation potential and toxicity information for Deca-BDE and Deca-BDE alternatives.

				Human Health Effects			Eco-toxicity					
Deca and Alternative	Product name	Use	React. or Add.	Cancer hazard	Non-cancer effects	Muta-genicity	Acute or chronic	Amt of tox. info	Potential routes of exposure	Persist-ence	Bioaccu. Potential	PBT?
Halogen-containing												
Deca-BDE (CAS# 1163-19-5)	SAYTEX 102E, DE-83R	Including HIPS	Add.	L	M	L	NI	M	Yes	Yes (PBDEs)	Yes (PBDEs)	Yes[1]
Bis(pentabromophenyl) ethane (CAS# 84852-53-9)	SAYTEX 8010, Firemaster 2100	Including HIPS	Add.	L	L	L	NI	L	Yes	Yes	No	No
1,2-bis(tetrabromophthalimido) ethane (CAS# 32588-76-4)	SAYTEX BT-93 and BT-93W	Including HIPS	Add.	L	L	L	L	L	NI	Yes	Yes	No
Tetrabromobisphenol A epichlorohydrin polymer (CAS# 40039-93-8)	EPON Resin 1163	Polystyrene	?	NI	L	L/NI	L	L	NI	NI	NI	NI
Bis(tribromophenoxy)ethane (CAS# 37853-59-1)	FF-680	Including HIPS	Add.	L	L	L	L	L - M	NI	Yes	Yes	No
Hexabromocyclododecane (HBCD) (CAS# 3194-55-6)	SAYTEX HP-900 and -9006L, SP-75 and CD-75P	Including HIPS	Add.	NI/L	NI	L	M	L	Yes	Yes	Yes	Yes[1]
Tetrabromobisphenol A (TBBPA) (CAS# 79-94-7)	SAYTEX CP-2000, BA-59P	Including HIPS	Add. in HIPS	L	M	L	H	M	Yes	Yes	Yes	Yes[1]
Tetrabromobisphenol A bis(2,3-dibromopropyl ether) (CAS# 21850-44-2)	SAYTEX HP-800A, -800AG, -800AGC, PE-68, 403AF	Including HIPS	Add.	M	L	H	NI	L	NI	NI	NI	NI

Table 1 (cont'd). Summary of use, persistence, bioaccumulation potential and toxicity information for Deca-BDE and Deca-BDE alternatives.

				Human Health Effects			Eco-toxicity					
Deca and Alternative	Product name	Use	React. or Add.	Cancer hazard	Non-cancer effects	Muta-genicity	Acute or chronic	Amt of tox. info	Potential routes of exposure	Persist-ence	Bioaccu. Potential	PBT?
Non-halogen												
Resorcinol bis (diphenylphosphate) (RDP) (CAS# 57583-54-7)	FyrolflexRDP, Reofos RDP	Including HIPS/PPO	Add.	NI	L	NI	M	L	NI	NI	NI	NI
Bisphenol A diphosphate (BAPP) (CAS# 181028-79-5)	Reofos BAPP	Including HIPS/PPO	Add.	NI	L	NI/L	L	L	NI	NI	Yes	No/ NI
Bisphenol A bis(diphenyl phosphate) (BDP) (CAS# 5945-33-5)	FyrolflexBDP, NcendX P-30	Including HIPS/PPO	Add.	NI	L	L	L	L	NI	NI	Yes	No/ NI
Diphenyl cresyl phosphate (DCP) (CAS# 26444-49-5)	?	Including HIPS/PPO	Add.	NI	M	L	M	L-M	NI	Yes	Yes	Yes
Triphenyl phosphate (TPP) (CAS# 115-86-6)	Included in products containing RDP at ~5-6%	Including HIPS, HIPS/PPO	Add.	L	L-M	L	M-H	M	Yes	L	L	No
Zinc Borate (CAS# 1332-07-6)	Firebrake ZB-467, -112, -237, -100	Including HIPS; synergist	Add.	NI	L	NI	M-H	L	Yes	NI	NI	NI (unlikely)

Kows and BCFs

Chemical	CAS #	Log Kow	BCF
1. Deca-BDE	1163-19-5	12.1	3.16
2. Bis(pentabromophenyl) ethane	84852-53-9	ND	ND
3. 1,2-bis(tetrabromophthalimido) ethane	32588-76-4	9.8	9.52
4. Tetrabromobisphenol A epichlorohydrin polymer	40039-93-8	ND	ND
5. Bis(tribromophenoxy)ethane	37853-59-1	9.15	74
6. Hexabromocyclododecane (HBCD)	3194-55-6	7.74	6210
7. Tetrabromobisphenol A (TBBPA)	79-94-7	7.2	13500
8. Tetrabromobisphenol A bis(2,3-dibromopropyl ether)	21850-44-2	11.5	3.16
9. Resorcinol bis (diphenylphosphate) (RDP)	57583-54-7	7.41	2960
10. Bisphenol A diphosphate (BAPP)	181028-79-5	4.0-5.2	ND
11. Bisphenol A bis(diphenyl phosphate) (BDP)	5945-33-5	>6	ND
12. Diphenyl cresyl phosphate (DCP)	26444-49-5	5.25	364
13. Triphenyl phosphate (TPP)	115-86-6	4.7	113
14. Zinc Borate	1332-07-6	ND	ND
15. Polytetrafluoroethylene (PTFE)	9002-84-0	ND	ND
16. Antimony trioxide	1309-64-4	6.23	12500

Log Kow and BCF from EPIWIN (http://www.syrres.com/esc/epi.htm), except BDP and BAPP (Aust., 2000). ND = No data

Summary

- We have identified a total of 13 alternatives for use in HIPS or HIPS/PPO
  - 7 halogen containing
  - 6 non-halogen
  - 2 related chemicals
- We are evaluating these alternatives relative to deca-BDE

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Summary

- Alternatives with concerns:
  - TBBPA and HBCD (both PBTs)
  - Tetrabromobisphenol A bis(2,3-dibromopropyl ether) (cancer and bioaccumulation potential)
  - Bis(pentabromophenyl)ethane (low mammalian toxicity, lack of aquatic toxicity information, persistence and bioaccumulation potential)
  - 1,2-bis(tetrabromophthalimido) ethane (low toxicity but little toxicity information, persistence and bioaccumulation potential)
  - Bis(tribromophenoxy)ethane (low toxicity, persistence and bioaccumulation potential)
  - Triphenyl phosphate and zinc borate (aquatic toxicity)
  - Diphenyl cresyl phosphate (toxicity, persistence and bioaccumulation potential)

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Summary

- Alternatives that are non-halogen but lack information:
  - Resorcinol bis (diphenylphosphate) (RDP)
  - Bisphenol A diphosphate (BAPP)
  - Bisphenol A bis(diphenyl phosphate (BDP)
- Alternatives that lack a significant amount of information
  - Tetrabromobisphenol A epichlorohydrin polymer

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Preliminary Conclusions

- We have not identified clear alternatives to Deca-BDE that:
  - Have lower toxicity, and
  - Have lower persistence and bioaccumulation potential, or
  - Have sufficient information for drawing conclusions about toxicity, persistence and bioaccumulation

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Future Work

- Continuing to gather information
  - Identify other alternatives
  - Identify other toxicity information
- Final summary of information about alternatives
  - Updating matrix
  - Updating chemicals in each category
    - Alternatives with no concerns
    - Alternatives with concerns
    - Alternatives lacking data

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Request for Information

- We are still collecting information on alternatives and/or toxicity studies
  - Are there other alternatives we should be evaluating?
  - Are there other toxicity studies we should be including?
- Please send additional information to:
  - Denise Laflamme
  - Denise.laflamme@doh.wa.gov

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